**Device and method for fastening balancing weights to rotors, in particular to propeller shafts or cardan shafts**

The invention relates to a device for fastening balancing weights to rotors comprising a plurality of compensation planes, in particular to propeller shafts or cardan shafts, preferably in a balancing machine which comprises at least one gripper-like device which can be positioned along the rotor axis, with which device a balancing weight can be placed on the outer periphery of the rotor and fastened there, and to a method for fastening balancing weights to rotors by means of the gripper-like device.

Devices and methods of the type mentioned at the outset are used in series production to economically balance relatively large unit numbers of rotors which comprise a plurality of compensation planes, for example propeller shafts or cardan shafts.

It is known from DE 44 40 812 A1 to arrange a rotor, for example a cardan shaft, in a balancing machine, to ascertain the imbalance in terms of size and angular position and to then place balancing weights in the compensation planes of the cardan shaft on the periphery of the rotor by means of at least one gripper-like device associated with the balancing machine, and to fasten them. For this purpose, the balancing weight is received by a unit of the gripper-like device, which gripper-like device is brought into the compensation position and the rotor rotated into the correct angular position. The balancing weight is then fastened, for example, by means of a gluing or welding operation. A gripper-like device is provided in each compensation plane for compensating imbalances in a plurality of compensation planes. Instead of this, a gripper-like device displaceable only along the rotor axis may be provided which is displaced into the relevant compensation plane in each case. Irrespective of whether one or more gripper-like devices are provided, there is expensive equipping of the gripper-like device with a balancing weight which is required at this balancing point for each balancing step.

The object of the invention is to allow a simple and inexpensive application of the requisite balancing weights in a device and a method of the type mentioned at the outset.

The object is achieved according to the invention in that, in a device of the type mentioned at the outset, the gripper-like device is constructed to receive a plurality of balancing weights. For fastening by means of the gripper-like device, a plurality of balancing weights is moved transversely to the longitudinal direction of the motor and a selected balancing weight is placed and fastened on the periphery of the rotor.

Fully automatic compensation of imbalances is easily possible with the invention, wherein all balancing weights for complete compensation of imbalances of a rotor are fastened to the rotor by means of just one gripper-like device, without intermediate provision of balancing weights being necessary. This also includes a second supplementary imbalance compensation step which may possibly be necessary and which takes place in a compensation plane of the rotor closely adjacent in the longitudinal direction thereof. The gripper-like device can advantageously be equipped with balancing weights at just one suitable loading station. This can take place by means of an automatic equipping device or else via the operator. The frequency and/or the duration of the equipping operation is reduced, so, for example, two balancing machines for propeller shafts or cardan shafts can be serviced by just one operator in quick succession. This applies in particular when only a single loading station is provided for equipping a plurality of balancing machines and this is ergonomically advantageously located, for example, between the balancing machines or is arranged at the ends thereof. Production costs are lower as a result of the lower complexity owing to only one gripper-like device and the simplification of equipping with balancing weights.

Advantageous in design is a configuration of the invention in which, in a gripper-like fastening device with two gripper units, preferably the lower unit comprises a receiver part, which can be displaced with respect to the unit and transversely to the longitudinal direction of the rotor, for receiving a plurality of balancing weights, as in this case conventional carriage solutions can be used and only small inertia masses have to be moved. By using the lower gripper unit a holding device for the received balancing weights can generally be dispensed with.

An embodiment of the invention in which the two gripper units can be jointly displaced along the rotor axis is very simple in construction.

In an embodiment of the invention wherein the receiver part comprises receivers for balancing weights which are arranged in the manner of a matrix transversely to the longitudinal direction of the rotor and in the longitudinal direction of the rotor, it is possible to keep in stock different forms of balancing weight or different balancing weight materials, for example sheet steel or strips of sheet aluminium for welding-on. Rotors which are different in terms of form or material may also be balanced in mixed operation. The application, in other words the placing and subsequent fastening of the balancing weights, is further simplified by a configuration in which the receiver part and the other gripper unit are displaceable relative to each other in the longitudinal direction of the rotor and both can preferably be jointly displaced transversely to the longitudinal direction of the rotor as the receiver with the selected balancing weight and the counter element can thus be quickly arranged opposite each other on the other gripper unit.

A further advantageous configuration of the invention provides that preferably the lower gripper unit comprises receivers for balancing weights arranged one behind the other and transversely to the longitudinal direction of the rotor, with which receivers, in the gripper closing direction, respective counter elements are associated in a corresponding number on the other gripper unit. Aligned opposing counter elements are therefore associated with each receiver and the selection and application of the selected balancing weight are possible by simple joint displacement of the two gripper units transversely to the longitudinal axis of the rotor without movable components being required for this.

Spot welding and projection welding can be used with a gripper-like device constructed as a welding device which comprises electrodes at both gripper units. Previously MIG and WIG welding were used for aluminium material but, in the meantime, projection welding of pre-shaped compensating sheets is also possible here.

A particularly simple method for applying the balancing weight provides that, in a gripper-like device comprising two gripper units, a plurality of balancing weights are received at preferably the lower gripper unit. These can be displaceably received via a receiver part for

the lower gripper unit or, instead, directly on the lower gripper unit such that they can only be moved together therewith.

Counter elements, whose number equals that of the balancing weights, are provided on the upper gripper unit in the application method of balancing weights non-displaceably arranged on the lower gripper unit and the two gripper units are displaced jointly transversely to the longitudinal direction of the rotor and, after placement of the selected balancing weight, the weight and the associated opposing counter element is brought to rest on the periphery of the rotor and fastened.

In the application with displacement of the receiver part, the selected balancing weight is placed on the upper gripper unit opposite a single counter element and fastened. With only one row of balancing weights arranged on the receiver part transversely to the longitudinal direction of the rotor, the receiver part is merely displaced on the lower gripper unit transversely to the longitudinal direction of the rotor, wherein only the application process in one compensation plane is observed.

If the balancing weights are provided in a plurality of rows, located one behind the other in the longitudinal direction of the rotor, in other words in a matrix-like manner on the receiving part at the lower gripper unit, then in an advantageous method the upper gripper unit, which does not carry any balancing weight, is not displaced on placement of the selected balancing weights, in other words is arranged opposite the balancing point. On placement of the selected balancing weight, the receiver part can be displaced transversely to the longitudinal direction of the rotor and in the longitudinal direction of the rotor. It may, however, also be provided that counter elements are arranged at the upper gripper unit in the transverse direction so as to correspond with the number of balancing weights lined up in a row of the lower gripper unit and subsequently a displacement of the receiver part in the longitudinal direction of the rotor on the lower gripper unit and a common displacement of lower and upper gripper unit takes place in the transverse direction. Finally, an arrangement of counter elements at the upper gripper unit in the longitudinal direction of the rotor in a number which corresponds to the number of rows of balancing weights located one behind the other at the lower gripper unit is possible. In this case the joint displacement takes place in the

longitudinal direction of the rotor and the displacement of the receiver part of the lower gripper unit in the transverse direction.

It is within the scope of the invention to provide the balancing weights on the upper gripper unit or on the upper and the lower gripper unit.

The invention will be described in more detail hereinafter with reference to embodiments illustrated in the drawings, in which:

Fig. 1 is a side view of a device for fastening balancing weights,

Fig. 2 is a front view of the device in Fig. 1,

Fig. 3 shows a portion of the device in Fig. 1,

Fig.4 shows a further embodiment of a portion of the device according to Fig. 1.

Fig. 1 schematically shows a balancing machine 1 in which a balancing rotor 2 is mounted. The balancing machine 1 comprises bearing devices not shown in greater detail for the rotor 2 to be balanced, at least one rotary drive, sensors for detecting the rotational behaviour of the rotor 2 and of imbalance-induced vibrations and an evaluation device for ascertaining the imbalance of the rotor 2. A device 3 for fastening balancing weights in a plurality of compensation planes of the rotor 2 is also arranged on the balancing machine 1.

In the x direction of a right angle coordinate system, as is symbolised in Fig. 2 by the double arrow x, the device 3 can be displaced on a guide rail 4 arranged on the frame of the balancing machine 1, along the axis of the rotor on which, in the illustration of Fig. 2, is located in the plane of the page. The guide rail 4 spans the balancing machine in the longitudinal direction of the rotor and is provided offset at the back, relative to the operator side, from the rotor axis. The device 3 can thus be displaced on the guide rail 4 in various compensation planes and subsequently be arrested.

The device 3 can also be displaced in the y direction, transversely to the rotor axis, as indicated by the double arrow y in Fig. 2, in order to allow mounting of the rotor 2 in the mounting devices of the balancing machine 1, or its removal. For mounting the rotor 2 or its removal, the device 3 is displaced from the operator side toward the offset guide rail 4. To allow fastening of balancing weights, the device 3 is returned in the direction of the rotor axis after mounting of the rotor 2.

The device 3 comprises a gripper-like device 5 with which a balancing weight can be placed in the respective compensation plane, on the external periphery of the rotor 2 and be fastened there. The gripper-like device 5 incorporates, as can be seen in more detail from Fig. 3 and 4, two gripper units 6, 7, which are mounted in the gripper closing direction indicated by the double arrow z so as to float relative to each other, which, with the aid of an advancing unit 8, can be moved relative to each other for increasing or reducing their spacing.

For fastening the balancing weights, the gripper-like device 5 is arranged with its gripper units 6, 7 on either side of the rotor 2 so as to partially surround it in such a way that the closing direction intersects the rotor axis. The gripper units 6, 7 are jointly movable at the periphery of the rotor by means of an advancing unit 8, until they abut on one of the gripper units 6, 7, in the illustrated embodiment, until they abut on the upper gripper unit 6 on the rotor 2. As soon as the upper gripper unit 6 rests on the rotor 2, the lower gripper unit 7 is also brought into contact with the rotor 2 via the counterforce of the advancing unit 8 acting on it. The movement of the lower gripper unit 7 is made possible here by a bearing of the gripper-like device 5, which bearing is floating in a gripper closing direction z on a carrier 12. To compensate for its weight, the gripper-like device 5 is supported here on the carrier 12 via a preferably pneumatic cylinder unit 9. The cylinder unit 9 is loaded with reduced pressure to compensate the weight. It can also be loaded at full pressure to raise the gripper-like device 3, when the rotor is not being used, to the extent that measuring bearing stands provided for mounting the rotor can be overrun in the x direction.

The lower gripper unit 7 is constructed to receive a plurality of balancing weights.

In the embodiment of Fig. 3 three receivers 7a, 7b and 7c are arranged one behind the other transversely to the longitudinal direction of the rotor 2 and can be jointly displaced on the lower gripper unit 7 by means of an actuating device 11. The receivers 7a, 7b, 7c can be provided on the receiver part 10 for joint displacement although the receivers 7a, 7b, 7c can also be displaceable one behind the other in a guide profile. For application of the balancing weight, selected for this compensation plane, situated in the receiver 7c and which is adapted in this compensation plane in terms of form to the periphery of the rotor, the receivers 7a, 7b, 7c from the arrangement illustrated in Fig. 3, in which the receiver 7a is aligned with the rotor axis, are jointly displaced into the position illustrated in Fig. 1 in which the receiver 7c with the selected balancing weight is aligned with the rotor axis. The gripper-like device 5 is accordingly moved in the closing direction until it abuts the upper gripper unit 6 on the rotor 2. The lower gripper unit 7 is then closed, the upper gripper unit 6 being used as a thrust bearing. The balancing weight in the receiver 7c is pressed against the periphery of the rotor and fastened to the rotor 2 by a welding process, the upper and the lower gripper units 6, 7 being used as electrodes. Once the gripper-like device 5 has been opened, the device 3 is moved into the next compensation plane and a further balancing weight is applied there, wherein prior to all application processes, the rotor 2 is rotated into the compensating angle position for this compensation plane, ascertained during the measuring phase. Once balancing weights have been applied in all compensation planes, the device 3 is returned in the direction of the guide rail 4, with the gripper-like device 5, the rotor 2 is removed and a rotor not subject to an imbalance is mounted in the balancing machine, the imbalance determined and the compensation made as described above.

In the embodiment of the gripper-like device 5 according to Fig. 4, three receivers 7a, 7b and 7c are arranged on the lower gripper unit 7 which cannot be displaced relative thereto. Three counter elements 6a, 6b and 6c on the upper gripper unit 6 are associated with the three receivers 7a, 7b and 7c on the lower gripper unit 7 so as to be aligned in the gripper closing direction. For application of the balancing weight selected from the three balancing weights for the respective compensation plane, for example of the balancing weight 7a for the rotor section with the smallest diameter illustrated in dot dash lines in Fig. 4, the entire gripper-like device 5 or the lower and upper gripper units 6, 7 with the receivers 7a, 7b, 7c non-displaceably arranged thereon and the counter elements 6a, 6b, 6c are displaced in such a way

that the rotor 2 is located with its axis aligned between the upper counter element 6 a and the lower receiver 7a. The application or welding process then takes place as described in more detail above.

In the described embodiments, the balancing weights are constructed as balancing metal sheets, of which the shape is adapted to the periphery of the rotor in the respective compensation plane. Once a rotor 2 has been compensated, the gripper-like device 5 is moved to a loading station for equipping of the three receivers 7a, 7b, 7c of the lower gripper unit 7 with balancing metal sheets which are to be used when the rotor is re-balanced. It goes without saying, that, if necessary, more than or fewer than three receivers, located one behind the other, for balancing weights can be provided.

In a modification to the development illustrated in Fig. 3, it can be provided, in a manner not shown in greater detail, that further rows of, for example, three receivers are provided one behind the other in the longitudinal direction of the rotor. This results overall in a matrix-like arrangement of receivers, these expediently being arranged on a receiver part which can be moved on the lower gripper unit. These receivers arranged on the receiver part which can be moved in the direction transverse to the longitudinal axis of the rotor and in the longitudinal direction of the rotor, can thus be equipped with balancing metal sheets such that, for example, rotors with different shapes or different materials can be balanced in mixed operation. For this purpose, the device is initially arranged in the desired compensation plane and then, for example, the receiver part is moved in the longitudinal direction of the rotor in accordance with the type of rotor to be balanced, until the respective row of three receivers of the associated balancing metal sheet is located in the plane in which the counter element of the upper gripper unit is also located. Application of the balancing metal sheets selected from this row of three takes place as described in more detail above with respect to Fig. 3, with displacement of the receiver part on the lower gripper unit.

However, it may also be provided that a number of individual counter elements is provided on the upper gripper unit which corresponds to the number of rows of three on the lower gripper units, so, for application, merely a displacement of the receiver part on the lower gripper unit is required in the transverse direction, irrespective obviously of the movement in

the gripper closing direction and the displacement of the device into the respective compensation plane. It is also very easily possible with this configuration to carry out a correcting balance by means of a second supplementary imbalance compensating step which takes place in a compensation plane closely adjacent in the longitudinal direction of the rotor as only one further pair of counter element and row of three is to be selected.

It also goes without saying that, instead of or in addition to the illustrated and described welding device, other known fastening devices, such as gluing devices, may also be used.

It is within the scope of the invention to physically separate the device for fastening balancing weights from the balancing machine if this proves to be advantageous, for example, for a production line. The rotor is then relocated from the balancing machine into the device, wherein information on the ascertained imbalance or compensating data resulting therefrom is passed on.